

**TECHNICAL ISSUES PERTINENT TO  
ASSESSING HEALTH RISKS POSED BY  
DIRECT CONTACT WITH METALS  
IN SURFACE MATERIALS AT  
THE METCOA RESTART SITE  
PULASKI, PENNSYLVANIA**

**Presented to**

**U.S. Environmental Protection Agency  
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## **I. INTRODUCTION**

Risk-based cleanup goals for metals in surface materials at the Metcoa/Pesses site in Pulaski, Pennsylvania ("the Site") were developed in the Management Options Analysis Report (MOAR) for the Site and were proposed to the U.S. Environmental Protection Agency (USEPA) in 1992 and again in 1994. Those cleanup goals were based upon a consideration of ingestion of and dermal contact with surface materials. Numeric response action (cleanup) goals were developed in the MOAR by using standard exposure factors that essentially assume that the surface materials at the Site are typical soils. Likewise, numeric response action goals developed by USEPA Region III personnel in 1994 implicitly assumed that the surface materials at the Site are typical soils. Numerous photographs, field reports, and site characterization data indicate, however, that the surface materials consist primarily of metal particles and slag, in addition to some soil-like materials.<sup>1</sup>

Since 1992 there have been major developments in how health risks posed by metals are assessed, particularly regarding lead in soil, slags, and ore residues. In light of these developments, ENVIRON reviewed the technical bases for the risk-based cleanup goals that were proposed in the MOAR and by USEPA Region III. This document represents a preliminary report on our findings. In addition to this introduction (Section I), there are three sections to this report, as follows:

- Section II provides a technical discussion of critical exposure assessment factors and recent research regarding their measurement and interpretation.
- Section III provides a preliminary indication of the potential differences in risk-based cleanup goals for metals that can result when site-specific physical and chemical characteristics are properly taken into account.
- Cited references are listed in Section IV.

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<sup>1</sup> Excerpts from the MOAR that describe the physical characteristics of surface materials at the Site are shown in Attachment A. See also Belanger [1986, p. 1], which reports that "A large amount of debris and slag as well as several hundred 55-gallon drums ... remain on the property."

## **II. TECHNICAL DEVELOPMENTS REGARDING EXPOSURE TO METALS**

### **A. Introduction**

The USEPA's recent *Soil Screening Guidance* indicates that for most chemical substances in contaminated surface soils, ingestion is a much more important route of systemic exposure compared to dermal permeation (USEPA 1994b).<sup>2</sup> This is particularly true for metals because, when dissolved (e.g., in perspiration), metals tend to exist in ionic forms that do not permeate skin readily. For these reasons, direct skin absorption is not anticipated to be a significant route of systemic exposure for the metals of potential concern at the Site (i.e., cadmium, nickel, and thorium). For these reasons, this discussion will focus on the health risks posed by gastrointestinal absorption resulting from ingestion of metals, not on dermal absorption.

There are three basic processes that dictate the degree to which metals ingested with soil become part of the total metal body burden:

- 1) Adherence of soil or metal particles to skin<sup>3</sup>
- 2) Ingestion of adhered metal or soil particles
- 3) Absorption of ingested metal-soil particles from the gastrointestinal (GI) system into blood

The available regulatory guidance and the published literature on these three areas were examined to determine whether there are sufficient data to warrant a reassessment of the numeric cleanup goals proposed for the Metcoa Site. The following is a discussion of these factors and how they can affect risk assessments. Although the metals of primary interest at

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<sup>2</sup> Calculations suggest that absorption via the dermal route must be at least 10% of that for the oral route for dermal exposure to equal or exceed the ingestion exposure (USEPA 1994b, p. 2-8). Available data indicate that few substances (e.g., pentachlorophenol) and no metals meet this criterion (USEPA 1994b, USEPA 1994c). For this reason, the draft USEPA Soil Screening Levels (SSLs) based upon direct contact with soil do not consider dermal exposure (USEPA 1994c). Likewise, USEPA Region III's risk-based concentrations for direct contact with soil are based upon ingestion, but not dermal, exposure (USEPA 1995a).

<sup>3</sup> Adherence is an important exposure factor for dermal routes of exposure also. Hence, the discussion of the adherence factor also has implications for assessing the risks of dermal exposure to metals.

the Site are cadmium, nickel, and thorium, data regarding lead, tungsten, and molybdenum were also reviewed, because certain characteristics regarding the adherence and ingestion metals and metal-containing soils may not be metal-specific.

#### **B. Adherence of Soil Particles to Skin**

There are two related issues when considering the adherence of Site surface materials to skin: (1) dermal adherence of soil particles containing metal and (2) dermal adherence of metal particles alone. This section summarizes several available studies regarding soil adherence to skin. We have not yet identified any comparable studies regarding adherence by metal particles.

Current thinking within the risk assessment community on appropriate soil adherence values for risk assessments can be summarized, as follows:

- There are two basic approaches to measuring soil adherence: (1) gravimetric studies using subjects that purposely and intimately contact soil; and (2) field studies that assay subjects engaged in various activities. The collection efficiency (accuracy) and reproducibility (precision) of gravimetric studies is believed to be better than that of field studies, as a general rule. On the other hand, field studies are more meaningful indicators of actual soil exposure, because gravimetric studies have generally examined adherence only to the hand and only under conditions of intimate soil/hand contact. Gravimetric studies that involve intimate soil contact may be representative only of activities like gardening that are of limited duration (Finley et al 1994) and, hence, may not be useful for predicting typical daily exposures.
- Soil properties can influence adherence (Kissel et al 1995). Adherence increases with moisture content and decreases with particle size (USEPA 1995b, p. 4-33). It is generally held that dirt and dust particles on children's hands tend to be less than 100  $\mu\text{m}$  in size (Duggan and Inskip 1985; Chaney 1988). Particles larger than 50  $\mu\text{m}$  (diameter) "do not adhere for any length of time to most surfaces" (Sheppard 1995). If the contaminant is restricted to particles greater than this size, then exposure from hand-to-mouth or adhesion-through-skin pathways "will be markedly reduced" (Sheppard 1995).

- Adherence levels vary considerably across different parts of the body (Kissel et al 1995). Use of soil adherence values for hands for skin surfaces other than hands may result in overestimation of the total amount of adhering soil (USEPA 1992, 1995b).
- Adherence levels vary with activity. The highest levels of soil adherence observed by Kissel et al (1995) in their USEPA-sponsored field studies were for outdoor workers, such as farmers and irrigation installers.

In its interim report in 1992, the USEPA recommended a soil-adherence range of 0.2 to 1.0 mg/cm<sup>2</sup> as reasonable values, based upon measurements of soil that adheres to hands after direct contact with soil. Based upon the findings of Kissel et al (1995) in their USEPA-sponsored field studies, "... changes are needed to the recommendations in USEPA 1992 regarding soil adherence. The new studies suggest a more site-specific approach is needed that considers the type of activity and uses different estimates for different regions of the body." (USEPA 1995b).

### C. Ingestion of Soil Particles

It is generally recognized that there is variability in this parameter from population to population, and site to site, and that the choice of an ingestion rate will likely have a significant effect on the results of any risk assessment. For example, the USEPA's *Risk Assessment Guidance for Superfund* notes that soil ingestion values vary depending on "site-specific or other information" (USEPA 1989).

There are basically two approaches to estimating soil ingestion rates: (1) analyses of human feces and/or urine for chemical "tracer" elements that are believed to be poorly absorbed in the gut; and (2) making predictions and extrapolations based upon a consideration of human activities that could lead to ingestion exposures. The pilot study of six adults by Calabrese et al (1990; as cited in USEPA 1995b, p. 2-400) is an example of the first, while Hawley's (1985) estimates are an example of the second. Coincidentally, the two methods

yield similar values of average soil ingestion rates for adults:<sup>4</sup> Calabrese's data suggest that soil intake among adults ranges from 30 to 110 mg/day (depending upon the tracer), while Hawley estimated an annual average of 60.5 mg/day. "This set of values is consistent with the 50 mg/day value often used by the program offices to represent mean soil intake rate by adults." (USEPA 1995b, p. 4-11).

Ingested soil is believed to result from three sources: (1) adherence of soil to skin followed by hand-to-mouth transfer; (2) adherence of soil to edible plants followed by their ingestion; and (3) ingestion of inhaled particulate. A consideration of each of these mechanisms leads to the conclusion that larger-sized particles will have a lower tendency to be ingested. For example, Sheppard (1995) states that several articles have "noted that particles larger than 50  $\mu\text{m}$  diameter do not adhere for any length of time to most surfaces. If the contaminant is restricted to particles greater than this size, then the exposure from the hand-to-mouth or adhesion-to-plant pathways will be markedly reduced." Mine wastes and paint chips are cited as examples. In addition, it is well known that the most of the dust that is generated by wind erosion of surface soils is primarily comprised of particles less than 45  $\mu\text{m}$  (Seinfeld 1986, USEPA 1987, USEPA 1995d) and that inhalable (respirable) soil particulate includes only those particles below 10  $\mu\text{m}$  (Hinds 1982). Larger suspended particles are trapped in the bronchiolar tree and generally swallowed. One paper suggested that "in adults, approximately 40% of inhaled lead is absorbed across the alveolar membrane or is removed by ciliary action from the respiratory tract and swallow. The amount retained will vary with particle size. The 40% figure is based on a 'normal' mixture of particles occurring in urban air" (NAS 1972). Therefore, the particle size distribution of surface materials is an important site-specific consideration in establishing soil/dust ingestion rates at a particular site.

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<sup>4</sup> Potential soil ingestion rates by adults are of greater interest at the Metcoa site than are those of children, because future land use will be industrial/commercial, if any development occurs. Risk-based response action goals for cadmium and nickel in surface materials were developed in the MOAR and by USEPA Region III personnel on the basis of future industrial land use and potential exposures of adult workers. These past efforts were consistent with more recent USEPA guidance promoting consideration of a reasonable future land use in order to ensure that any actions taken are cost-effective and practicable (e.g., USEPA 1995c).

#### **D. Oral Absorption of Metals**

It is appropriate in health risk assessments of ingestion exposures to consider the relative bioavailability<sup>5</sup> of a substance in the medium of concern at a particular site relative to that in the medium used to establish standard toxicity reference values, such as the oral Reference Doses (RfDs). For example, if an RfD has been established on the basis of a drinking water feeding study and that RfD is being used to estimate the non-cancer Hazard Quotient (HQ) for soil exposures, it is appropriate to consider the relative absorption of the substance from soil versus water. In other cases, the test medium and the medium of interest in the risk assessment are similar, but not identical (e.g., food with and without a corn oil additive); in these circumstances, it may also be critical to consider differences in physical conditions (e.g., particle sizes, co-occurring chemical substances) and incorporate a relative absorbability factor into the estimate of dose and risk. This section summarizes some of the factors that affect the absorption of metals from the gastrointestinal tract into blood and presents available data for cadmium, nickel, and thorium in particular.

##### **1. Factors**

The majority of experimental data on absorption of metals from the gastrointestinal tract focus on lead-containing soils. It is well known that several factors influence the absorption of lead from the gut, including diet, form of lead, and particle size (Marcus 1991). One group of researchers compiled information on residents of several different communities, all of whom lived in close proximity to mill tailings that had contributed to elevated levels of lead, cadmium, or arsenic in soils. They found no evidence of health effects or elevated blood lead levels due to these mill tailings. To explain this finding, the authors concluded that "in contrast to fine metallic dusts, metals in tailings or soils are unlikely to contribute to the lead body burden in humans because of large particle size, adsorption to soil, entrainment in a rock matrix, and low intrinsic solubility (Danse et al. 1991). These physical/chemical factors are discussed further in the remainder of this section.

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<sup>5</sup> Bioavailability refers to the amount of absorbed substance that enters the body through either mouth, skin, or other means and enters the general circulation, thereby permitting access to the site of toxic action.

**a. Binding of metals to soils**

In a recent review, Sheppard (1995) reported that soil can act as a competitive sink, thereby modifying the bioavailability of other elements and increasing or decreasing the gut transit time for a contaminated material. Most studies show that soil decreases bioavailability estimates, relative to those observed with salt solutions and soil-free food (Sheppard et al. 1995). Reported differences ranged from 5 to 20 times in the case of lead (Sheppard et al 1995).

A two-phase enzymatic procedure was developed to model *in vitro* the digestive process and then used this method to investigate the effects of soil on metal (i.e., cadmium, lead, cesium, mercury) bioavailability (Sheppard et al. 1995). Results showed that the levels of radiotracer metals in the fluid following enzymatic treatment decreased when soil was mixed with the administered contaminant. In particular, the percentage of the radiolabelled cadmium ( $^{115}\text{Cd}$ ) dose recovered in the final filtrate was 97% when no soil was added and 64% when soil was present (Sheppard et al. 1995). When stable (i.e., non-radioactive) elements were used, this effect was not observed, but the researchers theorize that the high concentration of stable metals required to facilitate detection resulted in exceeding the sorption capacity of the soil. The authors concluded that the bioavailability differences observed among soils are related to adsorption of the contaminant to soil particles (Sheppard et al. 1995).

Another group of researchers, examining the bioavailability of lead from soils at the Butte, Montana site, stated that "soil contains hydrous iron oxides, organic matter, and other adsorbing surfaces which may bind lead, thereby reducing absorption in the small intestine" (Freeman et al. 1992).

**b. Diet**

Although it has been shown that adult rats absorb approximately 1% of ingested lead, compared to 10% in adult humans, some researchers theorize that this difference is due to differences in diet rather than differences in absorptive function. As support for the influence of diet on absorption of lead, one study found that changing the normal rat chow to a low-mineral and high-fat diet enhanced absorption of lead "up to 50 times control values" (Baltrop and Meek 1979). The simple presence or absence of food at the time of lead ingestion, as well as the composition of the food, affect the absorption of lead from the GI tract (Clayton 1975).



Oral dosing experiments with human volunteers compared nickel absorption under fasting versus standard diet conditions. Fasting volunteers developed "marked hypernickemia within 4 hours of ingesting 5 mg of nickel as an aqueous solution of nickel sulfate" while control subjects did not develop "significant hypernickemia" (Sunderman 1992). Subsequent studies of nickel absorption in human subjects after oral administration of nickel sulfate ( $\text{NiSO}_4$ ) through either drinking water or added to food (scrambled eggs) were used to estimate gastrointestinal absorption of nickel. Nickel administered through drinking water was absorbed approximately 40 times more than a dose administered through food:  $27 \pm 17\%$  compared to  $0.7 \pm 0.4\%$ . These data suggest that the vehicle influenced the bioavailability of nickel. In this case, the aqueous nickel was significantly more available for absorption than the nickel combined with scrambled eggs. Related studies have shown that ascorbic acid, milk, coffee, tea, and orange juice all reduce the bioavailability of orally administered nickel in humans (Sunderman 1992).

#### c. Metal Species

A series of studies on lead-containing soils have attempted to define the effects of metal species on lead bioavailability. One study compared the dissolution of lead acetate [ $\text{Pb}(\text{OAc})_2$ ] compared to lead found in a mixture of soils taken from five mine waste sites (designated Soil 1) under simulated gastric conditions (Davis et al. 1992). Specifically, the solutions were kept at a pH of 1.3 for 2 hours (to simulate stomach conditions and retention time) and then titrated up to pH of 7.0 until equilibrium had been established (to simulate conditions and retention time in the small intestine; Davis et al. 1992). Under these conditions,  $\text{Pb}(\text{OAc})_2$  was 70 times more available than an equivalent mass of Pb in Soil 1 under simulated stomach conditions and 5 times more available under simulated small intestinal conditions (Davis et al. 1992). Under simulated small intestine conditions, the percent of lead solubilized from  $\text{Pb}(\text{OAc})_2$  and Soil 1 was 0.92% and 0.18%, respectively. The authors stated that "these results demonstrate that the use of soluble salts overestimates the availability of .. Pb from soils impacted by mining wastes" (Davis et al. 1992).

This same group of researchers used similar simulated gastric conditions to compare the *in vitro* bioavailability of lead in Soil 1 to pure anglesite ( $\text{PbSO}_4$ ; Ruby et al. 1992). Unlike the previous study, a constant pH of 1.3, 1.6, 2.0, 2.5, or 3.0 was

maintained for up to 250 hours. After 2 hours at pH 1.3 and 2.0, the amount of lead solubilized was equivalent to 20% and 40% (respectively) of the final equilibrium concentrations (Ruby et al. 1992). Lead dissolution from 180-250  $\mu\text{m}$  particles of  $\text{PbSO}_4$  and  $\text{Pb}(\text{OAc})_2$  was 40% and 100% of the final steady-state concentration, respectively, after 2 hr at pH 1.3. This relationship indicated that dissolution rates follow the order  $\text{Pb}(\text{OAc})_2 > \text{PbSO}_4 > \text{test soil}$  (Ruby et al. 1992)

The same group also examined the *in vivo* relative bioavailability of lead from soil versus lead acetate (Freeman et al. 1992). Two test soils, both derived from soils in the Butte area as described above, with lead concentrations of 810 ppm or 3908 ppm, were given to young rats at four different feeding levels, ranging from 0.2% to 5.0% of the diet, resulting in total concentrations of 1.62 to 195 ppm of lead in soil. After 30 days, all animals were sacrificed and lead levels determined in blood, bone, and liver. Lead levels in all three metabolic compartments were significantly higher in animals fed lead acetate than in animals fed test soil. Specifically, the blood compartment for animals fed soils had only 20% of the amount seen in animals fed lead acetate, the bone compartment only 9%, and the liver compartment only 8%.

#### d. Particle Size

Other researchers have investigated the effect of particle size on gastrointestinal absorption of lead in the rat. An inverse relationship was found between particle size and lead absorption and was most apparent in the 0 to 100  $\mu\text{m}$  range. A five-fold enhancement of absorption was observed when lead particles had a mean size of 6  $\mu\text{m}$ , compared with particles of 197  $\mu\text{m}$ . A second experiment, performed using a similar protocol, compared absorption from different sizes of lead paint particles and found that when particle size was reduced from the range of 500 to 1,000  $\mu\text{m}$  down to <50  $\mu\text{m}$ , blood lead increased 1.5 to 1.6 fold, and levels of lead in the kidney increased 1.5 to 1.8 fold (Baltrop and Meek 1979).

These data have led other researchers to examine the relationship between lead particle size and gastrointestinal absorption. A set of *in vitro* experiments using gastric fluid (obtained *in vivo*, source unspecified) to model digestion were performed using two lead sulfide preparations of different particle size: Preparation A had a mean particle size of 100  $\mu\text{m}$  and Preparation B had a mean particle size of 30  $\mu\text{m}$ . Although both compounds eventually reached the same maximum level of solubility,

as indicated by a plateau to the curve plotting solubility as a function of time, Preparation A required approximately twice as much time to reach that level (approximately 3 hours). The authors note that "with sample A it would be possible for much of the ingested material to pass through the gastro-intestinal tract before it could be converted to a form more readily absorbed" (Healy et al. 1982).

In another study, as part of an investigation of the effect of metallic state on bioavailability (Ruby et al. 1992, see previous section) the dissolution rates *in vitro* of six size classes of PbSO<sub>4</sub> particles ranging from 0-250  $\mu$ m were compared. The authors reported that "...dissolution rates at pH 1.3 were inversely proportional to particle size for the 250-180  $\mu$ m versus 90-1  $\mu$ m particles" and attributed this observation to the "large difference (350%) in initial surface area" (Ruby et al. 1992). They also note that initial dissolution rates for 180-250  $\mu$ m and 90-125  $\mu$ m particles were very similar, an effect that may be attributed to the smaller difference in surface area and/or variations in morphology.

This same group of researchers compared the bioavailability of lead acetate to lead in soil, using a rat model (Freeman et al. 1992, see previous section). As part of their discussion, they noted that "...in general, the lower the particle size, the greater the absorption of lead because smaller particles (higher surface area to mass) will dissolve more rapidly in the gastrointestinal tract, thus producing more solubilized lead" (Freeman et al. 1992).

In a discussion of the relative toxicity of inorganic lead, one review paper states: "Size is important. Lead absorption is greater from lead as small particles than from the same dose as large particles" (Mahaffey 1977). As a result, the greater the particle size, the lower the oral absorption and the lower the blood lead level (i.e., the potential magnitude and probability of adverse health effects are lower).

Steele et al (1990) developed equations that model the influence of particle size and lead compound solubility on the rate of lead absorption, using the prediction that the "rate of lead dissolved is directly proportional to both the solubility of the lead compound and the amount of lead on the surface (i.e., the surface area for a homogenous particle) available for interaction with the environment" (Steele et al. 1990). The predictions of Steele's model match well with the experimental data obtained by Baltrop and Meek (1979; discussed earlier), when the two curves are compared (Steele et al. 1990).

Considered together, these data and the opinions expressed by their authors support the conclusion that particle size and speciation of metals have significant effects on bioavailability.

## **2. Available Data for Site Metals**

The discussion above supports the conclusion that oral absorption of metals, in general, is affected by adsorption to soil, particle size, diet, and speciation. To be useful for risk assessment purposes, however, data specific for individual metals of interest at the Site would be needed. The following is a summary of data identified to date on specific Site metals.

### **a. Cadmium**

One study of the factors that influence cadmium absorption found that in rats, after weaning, gastrointestinal absorption of cadmium "decreased to less than 1%" (Kostial et al. 1979). This same study found that feeding the rats a milk diet pre- and post-dosage resulted in increased gastrointestinal absorption of cadmium. Other research, using quail as an experimental model, demonstrated that zinc supplements decreased overall cadmium retention (Spivey Fox et al. 1979).

A theoretical model of cadmium metabolism and distribution in humans resulted in estimation of the gastrointestinal absorption of cadmium at 3 to 10% (Nordberg and Kjellstrom 1979). These values resulted when the model was adjusted to give a "reasonable fit" to data that included groups of smokers (Swedish), persons newly employed in work involving cadmium exposure, persons with long-term occupational exposure, and persons in the Japanese general population, without occupational exposure who had different levels of daily cadmium intake from food (Nordberg and Kjellstrom 1979). The authors stated that data from recent work on gastrointestinal absorption of dietary cadmium in humans and rats indicate that an appropriate average value for gastrointestinal absorption of cadmium would be 5%, a value which is in agreement with their model.

**b. Nickel**

A group of researchers from the USEPA (Washington, DC) investigated the absolute absorption of nickel chloride (NiCl) and cadmium chloride (CdCl) adsorbed to either sand or clay loam. Control animals were given intravenous injections of CdCl or NiCl. After monitoring blood levels in rats for 48 hours, 3% of the NiCl bound to sand and 1.5% of NiCl bound to clay was absorbed. The values for CdCl were 0.5% and 0.1%, respectively. In addition to providing estimates of nickel and cadmium bioavailability, the authors concluded that "bioavailability of metals from soil appears to be primarily affected by the ionic state of the metal" and that "soil type becomes a factor affecting bioavailability" (Rubenstein et al. 1990).

**c. Thorium**

Values for gastrointestinal absorption of thorium have been reported to range from 0.02 to 1.0% (ATSDR 1990). One study found that solubility factors and particle size were the major determinants of absorption (ATSDR 1990). The ATSDR profile also cites work that showed, in rats, that "the rate of absorption of thorium-EDTA by the gastrointestinal tract was 60 times greater than that of thorium dioxide"; thorium nitrate "had a 4 times greater absorption rate than thorium dioxide"; and that "the absorption rate of thorium chloride was 10 or 20 times greater than thorium dioxide, depending on concentration". The absorption differences were attributed to different solubilities of the various chemical forms (ATSDR 1990).

### III. IMPLICATIONS

Numeric response action (cleanup) goals for cadmium and nickel for the METCOA Site were developed in the MOAR and subsequently revised by USEPA Region III personnel by using standard exposure factors that essentially assume that the surface materials at the Site are typical *soils*. Numerous photographs, field reports, and site characterization data indicate, however, that the surface materials consist primarily of *metal particles and slag*, in addition to some soil-like materials (see Attachment A). Because the surface materials at the Metcoa Site differ from typical soils in their particle size distribution and chemical form, adherence, ingestion, and oral absorption factors appropriate for the Site are also expected to differ from generic default values for soils.

To illustrate the potential implications of the research findings described in Section II, ENVIRON calculated risk-based response action goals for cadmium and nickel assuming a plausible set of alternative values for certain key exposure factors. The alternative values are listed in Table 1. Their basis can be summarized as follows:

- **Adherence Factor**

The response action goals for cadmium and nickel previously developed and proposed by USEPA Region III personnel were based upon a value of  $0.5 \text{ mg/cm}^2$  for the adherence factor. This value is the middle of the range of  $0.2$  to  $1.0 \text{ mg/cm}^2$  considered by the USEPA in 1992 to be plausible values for *soil*. Based upon the findings of Kissel et al (1995) in their USEPA-sponsored field studies, "... changes are needed to the recommendations in USEPA 1992 regarding soil adherence. The new studies suggest a more site-specific approach is needed that considers the type of activity and uses different estimates for different regions of the body." (USEPA 1995b).

The surface materials at the Site are primarily comprised of metal particles and slag, which, according to the the information presented in Section II, would be expected to have a lower adherence factor than soil, because of their larger particle sizes and other physical characteristics. The alternative value employed in this report to illustrate the impact of considering site-specific conditions is  $0.09 \text{ mg/cm}^2$ . It is the

average of the minimum and maximum values of soil adherence factors observed by Kissel et al. (1995) on the hands of grounds keepers. Because hands are expected to exhibit greater adherence than other skin surfaces, applying this value to the entire exposed skin area (assumed to be 2,000 cm<sup>2</sup> by USEPA Region III personnel) would tend to over-estimate exposure and risk, relative to using adherence factors reported by Kissel et al for arms, legs, face, and feet. In addition, any grounds keepers at the Site would be expected to have more intense (and frequent) contact with surface materials than would typical industrial/commercial workers. Finally, the alternative value is a measure of *soil* adherence not adherence of metal particles and slag. For these reasons, the appropriate site-specific adherence factor is expected to be even lower than the alternative value used in this illustration.

- **Ingestion Rate**

The response action goals for cadmium and nickel previously developed and proposed by USEPA Region III personnel were based upon a value of 100 mg/day for the ingestion factor. This value is at the high end of the range of 0.5 to 110 mg/day for adults, as recently summarized by USEPA (1995b). The alternative value employed in this report to illustrate the impact of considering site-specific conditions is 50 mg/day. It is a "value often used by the (USEPA) program offices to represent a mean *soil* (emphasis added) intake rate for adults" (USEPA 1995b, pp. 2-411 to 2-412). The surface materials at the Site are primarily comprised of metal particles and slag, which, according to the the information presented in Section II, would be expected to have an even lower ingestion factor, because of their larger particle sizes and other physical characteristics.

- **Oral Absorption Factors**

The response action goals for cadmium and nickel previously developed and proposed by USEPA Region III personnel were based upon a value of 100% for the oral absorption factors for cadmium and nickel. According to the the information presented in Section II, oral absorption factors for metals can be expected to be generally less than 100% and to be influenced by the vehicle or medium of dose administration. Specifically, oral absorption factors for metals have been reported to be as low 1% or less in the case of soil and soil-like materials. Available data for

cadmium and nickel were summarized in Section II. On the basis of these data, alternative values of 5% for cadmium (Nordberg and Kjellstrom 1979) and 3% for nickel (Rubinstein et al 1990) were used to illustrate the impact of considering site-specific conditions.

Attachment B presents the equations and summarizes the approach used to derive the response action goals. Essentially, the equations and approach are identical to those we understand to have been employed by USEPA Region III personnel, with the exception of the use of the alternative exposure factors cited in Table 1. In the case of cadmium, the resulting response action goal is 6,514 mg/kg, for the alternative set of exposure factor values shown in Table 1, compared to 700 mg/kg, as proposed by USEPA Region III personnel. In the case of nickel, the resulting response action goal is 125,000 mg/kg, for the alternative set of exposure factor values shown in Table 1, compared to 13,000 mg/kg, as proposed by USEPA Region III personnel.

USEPA's *Risk Assessment Guidance for Superfund* allows for and even encourages the appropriate use of site-specific information in conducting baseline risk assessments and developing risk-based response action goals (USEPA 1989a, 1991). The analysis presented above suggests that a proper incorporation of site-specific factors into the risk assessment for the Metcoa site could result in significantly higher cleanup goals, while still meeting the target Hazard Index previously set by USEPA Region III. Because the alternative exposure factor values are generally based upon data for *soils* (see Table 1), factor values for *metal particles and slag*, which are present in surface materials at the Site (see Attachment A) may be even lower, which, if true, would justify even higher response action goals than calculated here. The response action goals are based upon an assumption of 250 days per year of direct contact with surface materials, which likely over-estimates the exposure frequency for a typical worker in Pulaski, Pennsylvania, an area with snow and ice cover for a prolonged period each year. Hence, even higher response action goals would be obtained if a Site-appropriate exposure frequency would also have been assumed.

Based on the information and analysis presented in Section II, it is apparent that the risks posed by metals in surface materials at the Metcoa site are likely to be significantly lower than those posed by the same metals in soils at similar mass concentrations. The illustrative calculation described above indicates that the response action goals for the two sets of exposure factors may vary by a factor of ten times, indicating the importance of site-specific factors in



determining bioavailability of and health risks posed by metals. Because there may be a substantial difference in response action costs corresponding to these two alternative sets of response goals, the response action goals for cadmium, nickel, and thorium at the Site should be based upon a proper consideration of the unique site-specific physical and chemical characteristics of the Site.

<p style="text-align: center;"><b>TABLE 1</b>  <b>Summary of Alternative Exposure Factor Values</b>  <b>METCOA RESTART Site, Palmdale, Pennsylvania</b></p>			
<b>Exposure Factor</b>	<b>Generic Value Used by USEPA Region III<sup>a</sup></b>	<b>Alternative Value Based Upon Consideration of Site-specific Conditions</b>	<b>Rationale for Alternative Value</b>
<b>Adherence Factor (AF)</b>	0.51 mg/cm <sup>2</sup>	0.09 mg/cm <sup>2</sup>	Middle of range of soil adherence factors measured on beds of grounds keepers (Kimmel et al 1995; USEPA 1995b, Table 4-12).
<b>Ingestion Factor (IR<sub>i</sub>)</b>	100 mg/day	50 mg/day	"Value often used by program offices to represent mean soil (emphasis added) intake rate for adults" (USEPA 1995b, p. 2-411).
<b>Oral Absorption (ABS) for Cadmium</b>	1.00 (100%)	0.05 (5%)	Recommended typical value based upon model of cadmium metabolism and distribution (Nordberg and Kjellstrom 1979).
<b>Oral Absorption (ABS) for Nickel</b>	1.00 (100%)	0.03 (3%)	Results of rat study with nickel chloride bound to sand and clay (Rubinstein et al 1990).
<b>FOOTNOTES:</b>			
<p><sup>a</sup> See November 2, 1994 memorandum from J. Hubbard to J. Dodd entitled <i>Metcoa Radiation Site, Non-radioactive Metals Cleanup Levels: Summary of Issues</i> and November 18, 1994 memorandum from J. Dodd to W. F. Barton.</p>			

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**ATTACHMENT A**  
**EXCERPTS FROM THE MOAR REGARDING THE**  
**PHYSICAL CHARACTERISTICS OF SURFACE MATERIALS**

AR100342

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*Submitted to*

**ENVIRONMENTAL PROTECTION AGENCY, REGION III  
841 Chestnut Building  
Philadelphia, Pennsylvania**

**Pulaski, PA**



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**May 8, 1992**

**AR100343**

## **CHAPTER 2.0**

### **SITE CHARACTERIZATION**

#### **2.1 Introduction**

The METCOA Restart Site property boundary encompasses roughly 22-acres of partially wooded land located in a predominantly rural area 1 mile north of Pulaski, Lawrence County, Pennsylvania. The Site can be divided into 2 principal areas, a roughly 7-acre parcel of ground confined within a fence enclosing the former production area of the facility and the balance of the property located outside the fenced area. Of the grounds located outside the fenced area, all but an estimated 3-4 acres, located immediately north of the former production area, are wooded. The grounds within the fenced area are, for the most part, level and clear of heavy vegetation. The entire property is low-lying and, in areas, poorly drained. Within the fenced area is located a large industrial building, covering approximately 37,500 square feet, where the principal metal handling and processing activities of the former METCOA operation occurred. Except for a concrete pad along the southern side of the building and the entrance road/parking area on the north side of the building, the grounds within the fenced area are earthen and in places overgrown with brush. It appears that slag (including, reportedly, slag from a steel mill), metal scrap and assorted debris have accumulated in low-lying and poorly drained areas within the fenced portion of the property. Other areas are known to have been used historically for storage of incoming metal including scrap metal and production byproducts.

The objectives of the investigative portion of this study were to: identify if materials were buried on the Site; characterize the distribution of radioactive materials and non-radiological analytes across the Site; and determine, within the parameters of the approved sampling effort, if there has been movement or placement of these materials to areas within the boundaries of the property outside the fenced former production area.

#### **2.2 Description of Investigative Activities**

In accordance with the investigative methodology described in Work Plan No. 2 for the METCOA Restart Site, the property was defined in terms of 4 general areas to be characterized through sample collection and analysis. These 4 major subdivisions of the property are identified on Figure 1 of Appendix A. The largest of these was the open land located north and west of the fence surrounding the former production area (1-Acre Area Samples). Figure 2 in Appendix A shows the location of the 1-Acre Area samples and is immediately followed by a table of analytical results for these samples. Immediately outside the former production area, a 50-foot wide perimeter zone was established surrounding the fence (Perimeter Samples). Figure 3 in Appendix A shows the location of the Perimeter Samples and is immediately followed by a table of analytical results for these samples. Within the production area (fenced enclosure area), the investigation was divided between the exterior grounds and the building interior. The investigation of the grounds within the



in order to increase sample recovery rates. A description of the materials penetrated in each auger probe is provided on the Auger Boring Logs in Appendix B.

As stated previously, a micro R meter was used to screen each surface sample location prior to sample collection. A second micro R meter reading was taken of the surface soil sample in the stainless steel bowl following collection. With respect to the split-barrel samples, a micro R meter reading was taken after the split-barrel sampler was opened to determine if any portions of the sample contained radioactive material. The contents of the split-barrel were then transferred to a stainless steel bowl and the sample was homogenized. Due to the composition of certain samples from the fenced enclosure area (i.e., slag, debris, clay), it was not possible to completely homogenize each sample prior to placement into the sampling jar. If possible, the entire sample was placed into a glass soil jar. If the entire sample could not be placed into a single jar, an attempt was made to transfer a representative sub-sample of the material homogenized in the stainless steel bowl.

In general, the auger probes revealed the Site profile within the production area to consist of a surficial layer of slag and soil mixed with debris consisting of metal turnings, metal scrap, wood and plastic. The thickness of this material varied from about 0.5 to about 2.5 feet. No discrete buried wastes were encountered. Native soils consisting of sandstone, gravel, silt, and dark-colored clay grading to orange and gray-colored clay were encountered beneath the fill material. This assemblage of unconsolidated native materials is characteristic of a stream terrace, and was probably formed by Buchanan Run located just west of the former production area. The sandstone is probably derived from the lower unit of the underlying Shenango Formation, which comprises the bedrock beneath the site. In the areas located toward the western, northwestern, and northern portions of the former production area, the surficial layer is underlain by a dark brown to black-colored clay layer, which grades to a very stiff and relatively impermeable orange to gray-colored mottled clay layer within three (3) feet of the ground surface. The clay sequence appears to be areally extensive over this region of the property and is consistent with the observed poor surface water drainage. The ground water table was not identified in the auger probe borings, although a small amount of water was encountered perched on top of the previously described clay layer.

### **2.2.2 Test Pit Samples**

Following the completion of drilling activities, test pits were excavated to allow visual examination of the ground in profile. Each of 5 test pits was located along the axis of a radiological and/or magnetic anomaly, as proposed in the Interim Data Report. The actual position of each test pit in the field was adjusted, where possible, to center it over the highest micro R meter reading that could be detected in the vicinity of the test pit's proposed location. The surface soil sample was collected at the point where the micro R meter reading was the highest. Following the collection of the surface sample, the test pit was excavated to undisturbed native soil, typically 2.5 to 3 feet below the ground surface. The test pit walls were then scanned using a micro R meter to identify any elevated points

of radioactivity. Subsequent samples were collected from those areas of the test pit with elevated micro R meter readings. Field judgment was used to move the mid-wall sample to those areas with the highest micro R meter readings. The approximate location of each sample collected from the test pits is shown on the Test Pit/Trench Soil Sample Logs provided in Appendix C. The size and orientation of the sample point identifier (a rectangular box on the test pit logs) indicates approximately the area from which the sample was collected.

The test pits generally revealed a profile of the Site in the northwest and northern portions of the fenced enclosure area that consists of about 0.5 to 2.5 feet of slag and soil mixed with metal turnings, metal scrap, wood, plastic, wire, drum lids, tires and glass. In some locations, what appeared to be a pale yellow to orange-colored sandstone-like material was identified. In the vicinity of Test Pits 3, 4 and 5, it appeared that the ground surface had been raised by slag and assorted debris. In the process of excavating Test Pit 4 a crushed 55-gallon drum containing a white powder cake was encountered about a foot below the ground surface in the fill layer. A sample of this material was collected (MRS-TP4-1.5) and submitted to CEP for a Toxicity Characteristic Leaching Procedure (TCLP) test to determine if it is above any regulatory limits. The crushed drum and all traces of the white material it contained were excavated and placed next to the excavation under a plastic cover.

Below the fill material at almost every location was a well defined layer of dark gray to black colored clay that was very stiff and moist. This layer ranged in thickness from about 2 to 6 inches and graded into an orange and gray-colored mottled clay that was very stiff and moist. In most instances the upper surface of the black layer appeared to contain material similar to the fill layer. No fill materials were encountered below the base of the black horizon. Furthermore, there was no visual evidence in the walls of the test pits that these areas of investigation had been excavated previously.

Occasionally, small amounts of water would run into an excavation where a layer of low permeability had apparently impounded infiltrating precipitation. No evidence was observed of a water table in any of the test pits. Following the completion of each test pit, the excavations were filled by returning the materials in the reverse order of their removal.

### **2.2.3 1-Acre Area Parcels**

To ensure that the entire property was investigated, the grounds located outside the production area were divided into 11 parcels, each equalling approximately 1 acre in area, as shown on Figure 1 of Appendix A. With the exception of parcels 9, 10 and 11, the 1-Acre Area parcels are located in densely wooded terrain with moderate undergrowth. The open area north of the fenced enclosure was overgrown with brush and dense grass vegetation prior to the field work conducted under the initial Work Plan No. 2 investigations in the summer of 1991. This brush was cut to ground level in preparing the area for installation of the 5-meter grid stakes, as discussed in the Interim Data Report.

## **2.4 Discussion of the Analytical Results**

Collectively, the analytical results reveal that affected soils at the Site are confined to the surficial fill material within the fenced enclosure area. The ground surface in Areas D, E and F has been raised by about 0.5 to 2.5 feet of slag and miscellaneous debris material. Elevated concentrations of analytes at depths below 1 foot were only revealed in areas where the ground surface had been raised by slag, indicating that the source of the elevated analytes is the fill material. No areas of foreign/man-made materials that were physically buried below the natural ground surface were identified. Additionally, the analytical results indicate that downward migration of constituents into the native soils has not occurred.

With respect to the thorium analyses, a comparison of analytical data with field micro R meter readings show that analytically measured levels for thorium are typically lower than one would expect based upon those measurements taken with a hand-held meter prior to collecting the samples and of those taken of the sample itself. From visual observations and monitoring with a micro R meter during the field activities, it is apparent that the thoriated material is not finely and evenly distributed throughout the surface soil and fill material. Field observations indicate that the thoriated materials are generally small pieces of metal or slag that can be located within well defined points or pockets in the field measuring about a foot in diameter or less within the fenced enclosure area. These thoriated materials are of varying sizes (ie. thumbnail to grape fruit) and are not distinguishable by the eye from other surrounding slag materials and metal scrap without using a meter to measure radiation. Even then, without considerable effort, it was not possible to sift through the material in the field and identify the individual components emitting radiation. Because of the generally small but varying sizes of the thoriated materials, it was difficult to identify the actual piece of material affected. The strength of the radiation was observed to be great enough that a single piece of thoriated material could give a wider area the appearance of being radioactive.

The difficulty in discerning the thoriated material from surrounding materials became evident during the collection of samples from the test pits. Although an attempt was made to locate the highest region of radiation and to collect a surface sample at that point, none of the soil samples collected revealed laboratory thorium results correlative with the levels measured in the field. In general, a relatively high micro R meter reading would be detected at the ground surface. A surface soil sample would be collected and monitored in a background area revealing a considerably lower micro R meter level. The lab analytical results, in turn, usually revealed an even lower value. This suggests that thoriated materials exist, primarily, in isolated pockets and that the radioactive strength of the isolated pieces of thoriated material is sufficient to give the appearance of a larger area of impact. This also suggests that thoriated material has not migrated through or below soils beneath the defined production area. It appears that when field samples were collected, a few pieces of the thoriated material may have been included. This probably constituted a portion of the isolated pocket of thoriated material. When the laboratory collected a sub-sample of the material submitted for analysis it may or may not have included the portion of the

### **3.3.2 Development of Conceptual Model**

The materials of concern at the METCOA Site are metals and inorganics which previous field and laboratory observations indicate are relatively immobile in the environment. Observations made at the Site indicate that the inorganic constituents in soil exist primarily in the form of turnings, slag particles, or pieces of miscellaneous metal material. In this state, the materials are inert and practically immobile under normal environmental conditions. Previous Site investigations performed by EPA and others have characterized the physical setting of the Site (e.g., climate, meteorology, geologic setting, soils, and hydrogeology) in sufficient detail, and have shown that the groundwater is not a potential recipient or pathway of Site-related constituents. The conceptual model, therefore, focuses on the remaining potential soil, surface water, sediment, and air pathways.

The Site is currently secured and vacant (with the exception of periodic government and Response Group activities). No current demand exists for future use of the Site. The current owner of the Site, the Lawrence County Industrial Development Authority, has not expressed any specific plans for the future use of the Site. As a result, it is most probable that the Site will remain unoccupied for some time.

The building on-Site is currently used to house drummed materials. Certain potential response action options, which are discussed further in Chapter 4.0 and 5.0, contemplate the continued use of the building as an integral part of a possible response action at the Site. As with the remainder of the Site, the probable reasonable future use of the building is that it will remain vacant, other than for its utilization as part of any response action. In light of the indications that the present owner will cooperate with deed restrictions and will notify EPA of any proposed change in its use, the conceptual model considers the building's future use to be an integral part of the response actions at the Site. This model is particularly applicable because, in the options analyzed herein, any future use of the building that is inconsistent with its use as part of the response will require notice to and approval by EPA.

Consideration of the potential for future residential use of a site is usually included in any assessment. However, proper consideration must be given to the Site-specific circumstances in accordance with the NCP and current guidance in considering whether this assessment should be made. In particular, communications with the Lawrence County Planning Commission indicate that the Site's current zoning designation is for industrial use and that there is no reasonable expectation that the designation will change. Moreover, the current surrounding land use indicates the lack of any economic pressure to convert the Site from its present state to residential use. Further, representatives of Lawrence County Industrial Development Authority, the present owner of the Site, have indicated that the Authority would cooperate in a response option that would include deed restrictions and would require their notification to EPA that a future user intended to change the Site's present status. Future users could be required to comply with any EPA requirements and to gain EPA approval before commencing any activities or operations on the Site. Future residential use can therefore be eliminated as a reasonable potential use scenario for the Site. This

**ATTACHMENT B**  
**DERIVATION OF RISK-BASED RESPONSE ACTION GOALS**  
**BASED UPON ALTERNATIVE EXPOSURE FACTORS**

AR100349

## ATTACHMENT B

### DERIVATION OF RISK-BASED RESPONSE ACTION GOALS BASED UPON ALTERNATIVE EXPOSURE FACTORS

Numeric response action (cleanup) goals for cadmium and nickel for the METCOA Site were developed in the MOAR and subsequently revised by USEPA Region III personnel by using standard exposure factors that essentially assume that the surface materials at the Site are typical *soils*. Numerous photographs, field reports, and site characterization data indicate, however, that the surface materials consist primarily of *metal particles and slag*, in addition to some soil-like materials (see Attachment A). Because the surface materials at the Metcoa Site differ from typical soils in their particle size distribution and chemical form, adherence, ingestion, and oral absorption factors appropriate for the Site are also expected to differ from generic default values for soils. To illustrate the potential implications of the research findings described in Section II of this report, ENVIRON calculated risk-based response action goals for cadmium and nickel assuming a plausible set of alternative values for certain key exposure factors. The alternative values and their basis are described in Table 1 of the main report.

The non-cancer Hazard Quotient (HQ) was calculated for cadmium and nickel in this analysis using the same equations that we understand were employed by USEPA Region III personnel. As shown below, the total HQ for an on-site worker exposed to surface materials is assumed to be the sum of the HQs from dermal contact and incidental ingestion.

$$HQ_{total} = HQ_{ingest} + HQ_{dermal} \quad (1)$$

where:

$HQ_{total}$	=	Total hazard quotient
$HQ_{dermal}$	=	Hazard quotient from dermal contact with soil
$HQ_{ingest}$	=	Hazard quotient from incidental soil ingestion

The equations used to calculate the HQ-values for annualized exposures are as follows:

Incidental Ingestion:

$$HQ_{ingest} = \frac{C_s \times IR \times FI \times ABS_o \times EF}{BW \times 365 \times 10^6 \times RfD_{oral}} \quad (2)$$

where:

$C_s$	=	Upper-bound metal concentration in surface materials (mg/kg)
$IR$	=	Incidental ingestion rate (mg/day)
$FI$	=	Fraction of daily intake ingested while on-site (unitless)
$ABS_o$	=	Oral absorption factor (unitless)
$EF$	=	Exposure frequency (days/year)
$BW$	=	Body weight (kg)
$365$	=	Conversion factor to estimate annualized dose (days/year)
$10^6$	=	Conversion factor to estimate annualized dose (mg/kg)
$RfD_{oral}$	=	Chronic reference dose for the oral route (mg/kg-day)

Dermal Contact:

$$HQ_{dermal} = \frac{C_s \times SA \times AF \times ABS_d \times EF}{BW \times 365 \times 10^6 \times RfD_{dermal}} \quad (3)$$

where:

$SA$	=	Skin surface area exposed (cm <sup>2</sup> )
$AF$	=	Adherence-to-skin factor (mg/cm <sup>2</sup> -day)
$ABS_d$	=	Dermal absorption factor (unitless)
$RfD_{dermal}$	=	Chronic reference dose for the dermal route (mg/kg-day)

and all other factors are as described previously. The total HQ value for cadmium ( $HQ_{total,Cd}$ ) was developed using USEPA's refereed oral RfD ( $RfD_{oral,Cd} = 1 \times 10^{-3}$  mg/kg-day) and the allowable daily dose for dermal exposure derived by USEPA Region III personnel ( $RfD_{dermal,Cd} = 2.5 \times 10^{-5}$  mg/kg-day). The total HQ value for nickel ( $HQ_{total,Ni}$ ) was developed using the renal-specific, allowable daily dose developed by Environmental Standards and adopted by USEPA Region III ( $RfD_{oral,Ni} = 5 \times 10^{-3}$  mg/kg-day) and the allowable daily dose for dermal

exposure derived by USEPA Region III personnel ( $RfD_{\text{dermal, Ni}} = 5 \times 10^{-4}$  mg/kg-day). The cumulative Hazard Index (HI) for these two metals was computed by summing the substance-specific HQ values (i.e.,  $HI = HQ_{\text{total, Cd}} + HQ_{\text{total, Ni}}$ ). The  $HQ_{\text{total}}$  and HI values were calculated using exposure factor values identical to those we understand to have been used by USEPA Region III personnel, with the exception of the alternative values listed in Table 1 of the main report. The "site-wide" 95%UCLM values (i.e., for fenced and perimeter areas) that are based upon the assumption of a lognormal distribution for the sample concentrations for cadmium and nickel were used in these calculations. Table B-1 shows these concentrations and exposure factors and the resulting HQ and HI values.

Response action goals for cadmium and nickel were calculated by combining equations 1 through 3 and inverting to yield an equation expressed for concentration (i.e., the risk-based response action goal) in terms of an allowable value for the substance-specific Hazard Quotient ( $HQ_{\text{allow}}$ ). For this illustration, the values of  $HQ_{\text{allow}}$  were established by apportioning to cadmium and nickel according to the contribution of  $HQ_{\text{total, Cd}}$  and  $HQ_{\text{total, Ni}}$  to HI, as follows:

$$HQ_{\text{allow, Cd}} = \frac{HQ_{\text{total, Cd}}}{HI} \quad (4)$$

$$HQ_{\text{allow, Ni}} = \frac{HQ_{\text{total, Ni}}}{HI} \quad (5)$$

In this way, the allowable Hazard Index is set at unity ( $HI_{\text{allow}} = HQ_{\text{allow, Cd}} + HQ_{\text{allow, Ni}} = 1$ ). This procedure was used to calculate alternative response action goals for cadmium and nickel, as shown in Table B-1. The approach employed is identical to that which we understand to have been used by USEPA Region III personnel. To verify this understanding, we used the equations and procedure described above with all of the USEPA Region III exposure factor values to generate the USEPA response action goals, as shown in Table B-2.



TABLE B-1

Pathway: Soil Contact

Exposure Parameters - General		Alternative Factor Values
Body weight	=	70.0 kg
Averaging time (noncarcinogens)	=	9,125 days
Averaging time (carcinogens)	=	25,550 days
Exposure duration	=	25 yrs
Exposure Parameters - Soil : Incidental Ingestion		
Ingestion rate, daily	=	50.0 mg/day
Fraction ingested while on-site	=	0.5 (unitless)
Exposure frequency	=	250 days/yr
Exposure Parameters - Soil: Dermal Contact		
Exposed Skin Surface Area	=	2,000 sq cm
Soil/Skin Adherence Factor	=	0.09 mg/eq cm-day
Exposure frequency	=	250 days/yr
NON-CANCER REFERENCE VALUES		
Chemical Substance of Interest	"Site-wide" 95%UCLM Soil Conc. (mg/kg)	1733.0
	Oral RfD (mg/kg-day)	1.00E-03
cadmium- lognormal assumption	Dermal RfD (mg/kg-day)	2.50E-05
nickel- lognormal assumption		5.00E-02
		5.00E-04

POINT ESTIMATE CALCULATIONS

ABSORPTION FACTORS		HQ ESTIMATES FOR WORKERS				RISK-BASED RESPONSE ACTION GOALS	
Oral	Dermal	Soil Ingestion	Soil Dermal	Soil TOTAL	Target HQ allow	Target Conc. (mg/kg)	
0.05	0.001	0.021	0.122	0.143	0.539	6,514	
0.03	0.001	0.005	0.118	0.123	0.461	125,757	
HI = 0.266					1 = HI allow		

TABLE B-2

## Pathway: Soil Contact

## USEPA

Exposure Parameters - General

Body weight	=	70.0 kg
Averaging time (noncarcinogens)	=	8,125 days
Averaging time (carcinogens)	=	25,550 days
Exposure duration	=	25 yrs

Exposure Parameters - Soil: Incidental Ingestion

Ingestion rate, daily	=	100.0 mg/day
Fraction ingested while on-site	=	0.5 (unitless)
Exposure frequency	=	250 days/yr

Exposure Parameters - Soil: Dermal Contact

Exposed Skin Surface Area	=	2,000 sq cm
Soil/Skin Adherence Factor	=	0.51 mg/sq cm-day
Exposure frequency	=	250 days/yr

## NON-CANCER REFERENCE VALUES

"Site-wide"  
95%UCLM

Chemical Substance of Interest	Soil Conc.	Oral RfD	Dermal RfD
	(mg/kg)	(mg/kg-day)	(mg/kg-day)
cadmium- lognormal assumption	1733.0	1.00E-03	2.50E-05
nickel- lognormal assumption	33458.0	5.00E-02	5.00E-04

## POINT ESTIMATE CALCULATIONS

## ABSORPTION FACTORS

## HQ ESTIMATES FOR WORKERS

## RISK-BASED RESPONSE ACTION GOALS

HI = 2.535

1 = HI allow

# ENVIRON

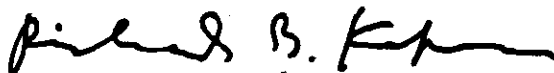
August 18, 1995

Laura Ahearn, Esq.  
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Washington, DC 20037-1420

Dear Ms. Ahearn:

Enclosed please find for your files and review one bound copy of ENVIRON's report entitled *Technical Issues Pertinent to Assessing Health Risks Posed by Direct Contact with Metals in Surface Materials at the METCOA Restart Site Pulaski, Pennsylvania*. Per your request, I have also sent copies to the individuals named on the attached distribution list.

Very truly yours,



Richard B. Kapuscinski, Ph.D.  
Manager

Enclosure

cc: Distribution List

**Distribution List:**

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